DEVELOPING A METHODOLOGY USING OBJECT-BASED ANALYSIS TO ASSESS THE URBAN CONDITION OF MADRID

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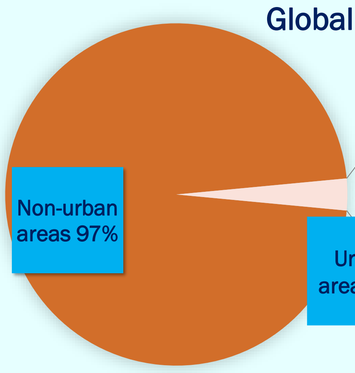
INTRODUCTION

Global scale



> 65% GHG emissions

Urbanization → 2nd greatest pressure on natural ecosystems

Sustainable Development Goals (SDG) on Cities → Goal Nº **11**

Goals Nº **1**, **10**, **8** and **13**

Importance of cities in the 2030 Agenda

Madrid

3rd **most populated** city in the EU

3rd European city with the largest **extension of green areas** (2018)

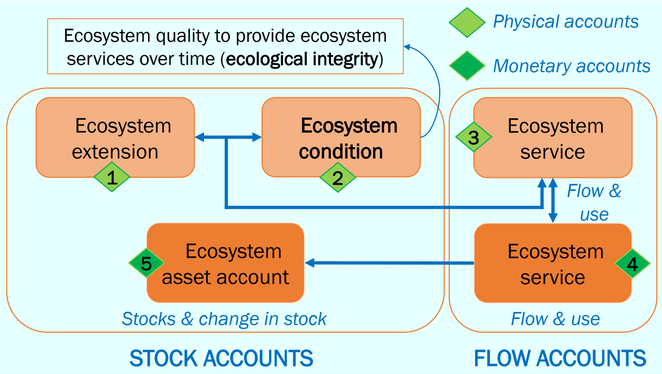
↑ 724% of **artificial** urban **surfaces** (1950 – 2005)

*Need to **include natural capital in socioeconomic and political decision-making** in cities to achieve sustainable urban development.*

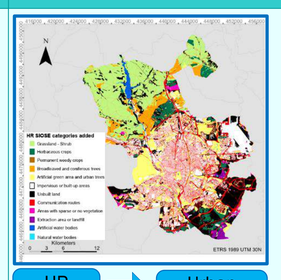
System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA) (United Nations)

*Common methodology for accounting and evaluating **natural capital***

Integrated standard spatially based statistical framework to inventory stocks and flows of any ecosystem



MATERIALS AND METHODS



HR SIOSE → Urban categories (1)

Polygons

Sources

Abiotic ecosystem characteristics: Physics, Chemistry

Biotic ecosystem characteristics: Composition, Function, Structure

Landscape characteristics: Landscape

(2) **Variables**

- Perviousness
- Normalised Difference Moisture Index (NDMI)
- Quietness index
- Cooling effect
- Lack of air pollutants (NO_2, O_3, CO, SO_2, CHOH) and water vapour concentration
- Communitarian interest in bird species richness
- Proximity to semi-natural and natural riparian Greenness or Normalized Difference Vegetation Index (NDVI) annual maximum
- Tree canopy cover
- Ecosystem fragmentation (forest area density (FAD))

Spatial resolution: 30 meters

El Pardo Mount

(3) **Condition reference polygon**

Polygon value - reference polygon value

∑ (weighted Euclidean distance of indicators)

(5) **Condition index** (0 – 1)

Polygon with highest average

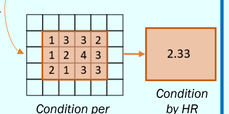
> 30%

3-30-300 Rule

Average per polygon of the HR SIOSE

(4) **Indicators**

Description of the average long-term behavior of the ecosystem



Condition per pixel

Condition by HR SIOSE polygon

The **HR SIOSE polygons** have been the basis of the **evaluation by objects**, calculating for each polygon the average condition of the pixels included in them.

All variables have been obtained from **remote sensing** sources to allow the inclusion of a **detailed spatial and temporal scale.**

To obtain the **condition reference values**, several criteria have been applied, highlighting the **3-30-300 Rule**: people must see 3 trees from their home, have a 30% fraction of tree cover in their neighborhood and live less than of 300 meters of high-quality green space (at least 0.5 hectares in size).

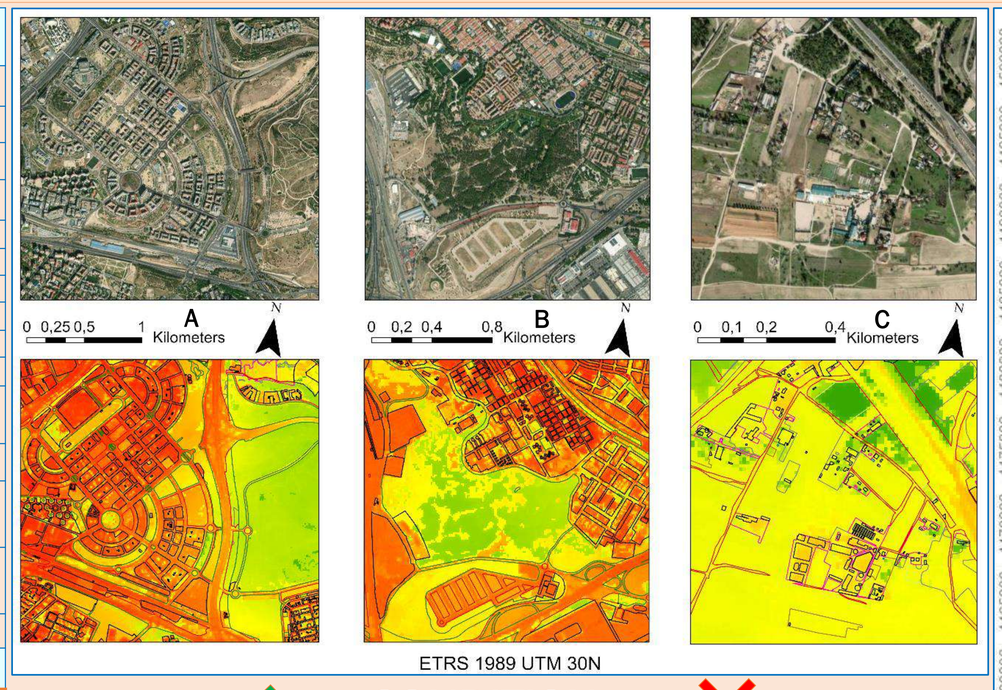
Reference area: **El Pardo Mount**, area with the greatest provision of ecosystem services (highest condition).

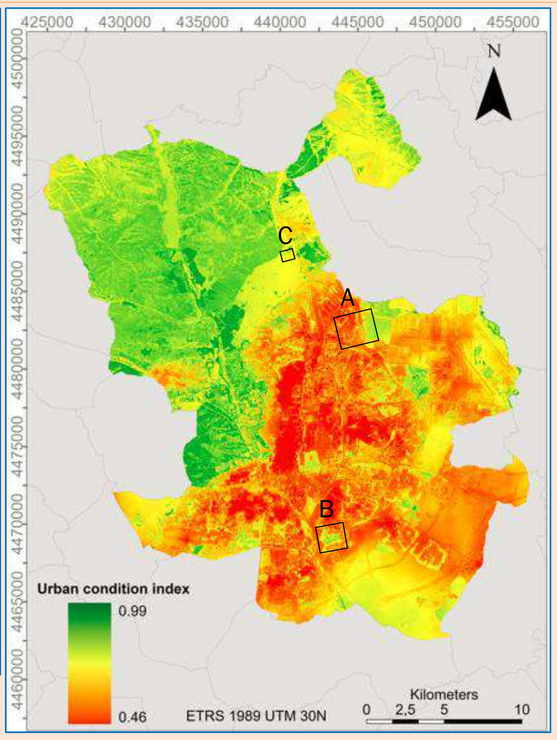
Use of the **weighted Euclidean distance** to calculate the indicators (↑ distance between a polygon and the reference one, ↓ similarity of the values of the variables between both polygons, ↓ condition of the evaluated polygon).

This method allows **evaluating spatially unique and real objects**, avoiding atypical maximum and minimum values.

RESULTS AND DISCUSSION

Variable group	Variables	Reference value	Variable value	Indicator	Weight	Weighted indicators
Physics	Perviousness	1.000	0.729	0.073	0.025	0.002
	NDMI	0.717	0.514	0.041	0.100	0.004
	Cooling effect	0.567	0.398	0.029	0.050	0.001
	Quietness index	0.922	0.751	0.029	0.050	0.001
Chemicals	Lack of NO_2	0.572	0.357	0.046	0.050	0.002
	Lack of O_3	0.807	0.466	0.116	0.050	**0.006**
	Lack of CO	0.327	0.329	0	0.025	0
	Lack of SO_2	0.446	0.498	0.003	0.025	0
	Lack of CHOH	0.609	0.535	0.005	0.025	0
	Water vapour	0.845	0.748	0.009	0.050	0
Composition	Bird species richness	0.739	0.488	0.063	0.150	**0.009**
Function	Greenness	0.704	0.596	0.012	0.100	0.001
	Proximity to riparian areas	0.920	0.665	0.065	0.050	0.003
Structure	Tree canopy cover	0.635	0.140	0.246	0.150	**0.037**
Landscape	FAD	0.620	0.101	0.270	0.100	**0.027**
				Euclidean distance		0.309
				Condition index		0.691





Most relevant condition indicators

- Landscape (*FAD*) → ↑ condition: ↑ connectivity and ↑ integrity of green infrastructure in the ecosystem
- Ecosystem **structure** (*tree canopy cover*)
- Ecosystem **composition** (*bird species richness*) → ↑ condition: ↑ bird richness ↔ ↑ ecological status (good functioning of the ecosystem)
- Ecosystem **quemistry** (*lack of O_3*) → ↑ condition: ↓[O_3] ↔ ↓ pollution and ↓ diseases

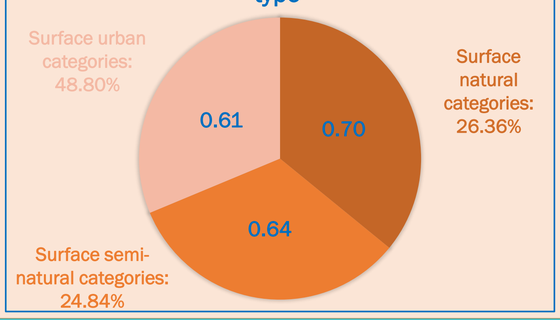
CONDITION

- **Northwest** of Madrid
- Spatial proximity and ecological characteristics like the reference polygon
- Far from pollution sources
- **23.66%** of neighborhoods (**cond > 0.60**)

- **Central areas** of Madrid
- Increased **air and noise pollution**
  - → Road traffic
  - → Scattered and sparse tres
- Water and thermal problems → Imperviousness soil
- **76.34%** of neighborhoods (**cond ≤ 0.60**)

The evaluation of the **condition** of an ecosystem must refer to the **conservation of the integrity of the ecosystem**, this being understood as the capacity of the ecosystem to maintain its composition, structure and functioning in the long term, allowing the **provision of services** and benefits to the human population.

Average condition index by category type



CONCLUSIONS

- There is **limited experience in accounting for urban ecosystems**, with condition accounts being those that present the lowest level of development, unlike extension and ecosystem services accounts. So, the proposed methodology, based on the SEEA-EA framework, represents progress in the development of condition accounts.
- The generation of **indicators from remote sensing** sources and techniques has made it possible to **accurately evaluate the urban condition** by including precise spatial (microscale) and temporal information, **facilitating the replicability** of the methodology in other urban ecosystems **and** allowing the **inclusion of natural capital in planning and policy formulation.**
- It has been identified that the integrity of the ecosystem (**FAD**), as well as its structure (**tree canopy cover**), composition (**bird richness**) and chemistry (**O_3**), have **a greater influence on the change in urban condition**, so It would be important to focus efforts on these variables to improve the urban condition of Madrid and thus ensure the provision of ecosystem services.
- The areas with **higher condition** present ecological characteristics **like El Pardo Mount**, while the areas with **low condition** are **extensive urbanized areas**, have **less vegetation** and are **close to the main sources of urban pollution.**
- The **condition index** can be used **to evaluate the effectiveness of urban policies** over a period. An increase in the index would suggest the success of the policies implemented, while a decrease would signal the need to reorient these policies and carry out urgent interventions. Cities can also use this methodology as a tool to analyze the **city's resilience to climate change**, **project its future trend**, **identify inequalities in the distribution of natural resources**, **track the provision of ecosystem services** and guide **and prioritize its investments of green infrastructure.**
- **Object-based analysis**, **reduction of operating costs**, the ability to **include an integrated vision of the ecosystem**, methodological **simplicity and flexibility**, **less dependence on human judgment**, the **possibility of capturing complex** (non-linear) urban **dynamics and** obtaining **easily interpretable results** are some of the advantages that this methodology presents over other current metrics.
- This index could serve as a basis for the **Green Infrastructure and Biodiversity Plan** or the **Madrid Strategic Plan**, but its alignment and compatibility with the methodologies of current regulations is required. Furthermore, it is suggested to integrate innovative digital technologies and green digital networks into ecosystem accounts.
- At an urban scale, the **ecosystem condition** must be the **principle** by which the current economy focused on GDP is transformed into an **economy of management and care of the planet**, since human physical and mental health depends on the health of nature.

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